Columbia University
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LAMONT GEOLOGICAL OBSERVATORY
PALISADES, NEW YORK

Technical Report No 7

[Contract NObsr 43355]

Investigation of Existence of Echo Bank by Topographic Echo Technique

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(Columbia University)

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by

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ABSTRACT

As part of the program of AMOS Cruise 12, an attempt was made to determine the existence and location of Echo Bank. The search, entitled Event Charlie, was divided into two phases: Phase I consisting of nine 55# charges exploded at positions calculated to give echoes at the Bermuda SOFAR installation and Phase II consisting of seventeen 2-1/2# charges exploded on a line such that Echo Bank might be expected to block direct transmission to Bermuda on one or more of the shots.[1] The shots of Phase I produced no echoes from submarine topography at or near the reported location of Echo Bank although echoes were received from three known reflectors in the Lesser Antilles. The results of Phase II are inconclusive because of duds and improper location of the shot line.

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1. Ewing et al., Recent Results in Submarine Geophysics, Bull. Geol. Soc. Amer. Vol. 57, p. 932, Oct. 1946.

INTRODUCTION

The existence of Echo Bank has for some time been in doubt. An echo sounding search was made at the reported location by R/V ATLANTIS in the spring of 1950 and showed no sign of the Bank. Subsequent investigations using topographic echoes from explosive charges have indicated that no reflector exists at the reported location. Luskin et al. (Submarine Topographic Echoes from Explosive Sound) expresses a doubt as to the existence of Echo Bank since no echoes received had a symmetrical solution to within 100 miles of the reported location.

During the planning for AMOS Cruise 12 it was decided that charges exploded close to the reported location should produce echoes if a reflector exists. A search was planned whereby, in addition to monitoring by the Bermuda SOFAR Station, U. S. S. REHOBOTH would receive at position 21°43'N. Lat. 58°56'W. Long. and U. S. S. SAN PABLO would drop charges as shown in the track chart, Fig. 1. If consistent echoes were received by REHOBOTH, SAN PABLO would be directed to the source to conduct an echo sounding search. This plan was executed and no reflection was determined. SAN PABLO then dropped charges on an East-West

line south of the reported location of the bank which would supposedly cast an "acoustical shadow" at Bermuda. However, numerous duds, improper location of the shot line, and uncertainty about shot instants, make this data inconclusive. It will not be reported unless additional data removes the uncertainty.

ACKNOWLEDGMENTS

Dr. Maurice Ewing, Director of the Lamont Geological Observatory, and Gordon Hamilton, Chief Scientist of the Columbia University Geophysical Field Station, gave valuable advice and criticism of the analysis of the data.

Valuable assistance was received in conducting the event from Ezra Smith and Fulton M. J. Brown of Lamont Geological Observatory, Edward Hazelwood of the U.S. Navy Hydrographic Office, Henry Johnson of Woods Hole Oceanographic Institution, personnel of the U.S. Navy Underwater Sound Laboratory at New London, Conn., personnel of the Bermuda SOFAR Station, and from the officers and enlisted men of the U.S. Navy Hydrographic Office vessels U.S.S. SAN PABLO and U.S.S. REHOBOTH.

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RESULTS

The shot times and positions of Shots S.P. #1 - 9 are listed in Table I, and the travel times of these shots recorded at Bermuda are listed in Table II. S.P. #1 was not recorded by

SAN PABLO and the explosion instant was determined by the arrival time at Bermuda and the travel time obtained from the other shots. S. P. #3 was a dud and during S. P. #4 and S. P. #5 the Bermuda High Point hydrophone was inoperative although the shots were received by the Cove Point geophone.

Echoes were received from all shots except S. P. #5 which had interference from a shot apparently fired somewhere to the Southwest of Bermuda and arrived at the time to mask an echo from the SAN PABLO shot. Consistent echoes from four reflectors were obtained on all other shots. The locations of the reflectors are shown in Figs. 2 and 3. An echo from the neighborhood of Echo Bank would necessarily have arrived at Bermuda with a delay of less than sixty seconds after the direct wave, and this is definitely not observed. Furthermore, the reported location of Echo Bank bears approximately 150° T from the midpoint of a line between the two receivers. A signal from this direction would arrive at the two instruments almost simultaneously, but all observed echoes arrive at High Point at least 15 seconds ahead of Cove Point, indicating the direction of the reflections to be well to the west of Echo Bank.

The only close echo appears about 14 seconds after the direct wave and has been determined not to be from the Echo Bank area for the following reasons: (a) The delay of the echo from the

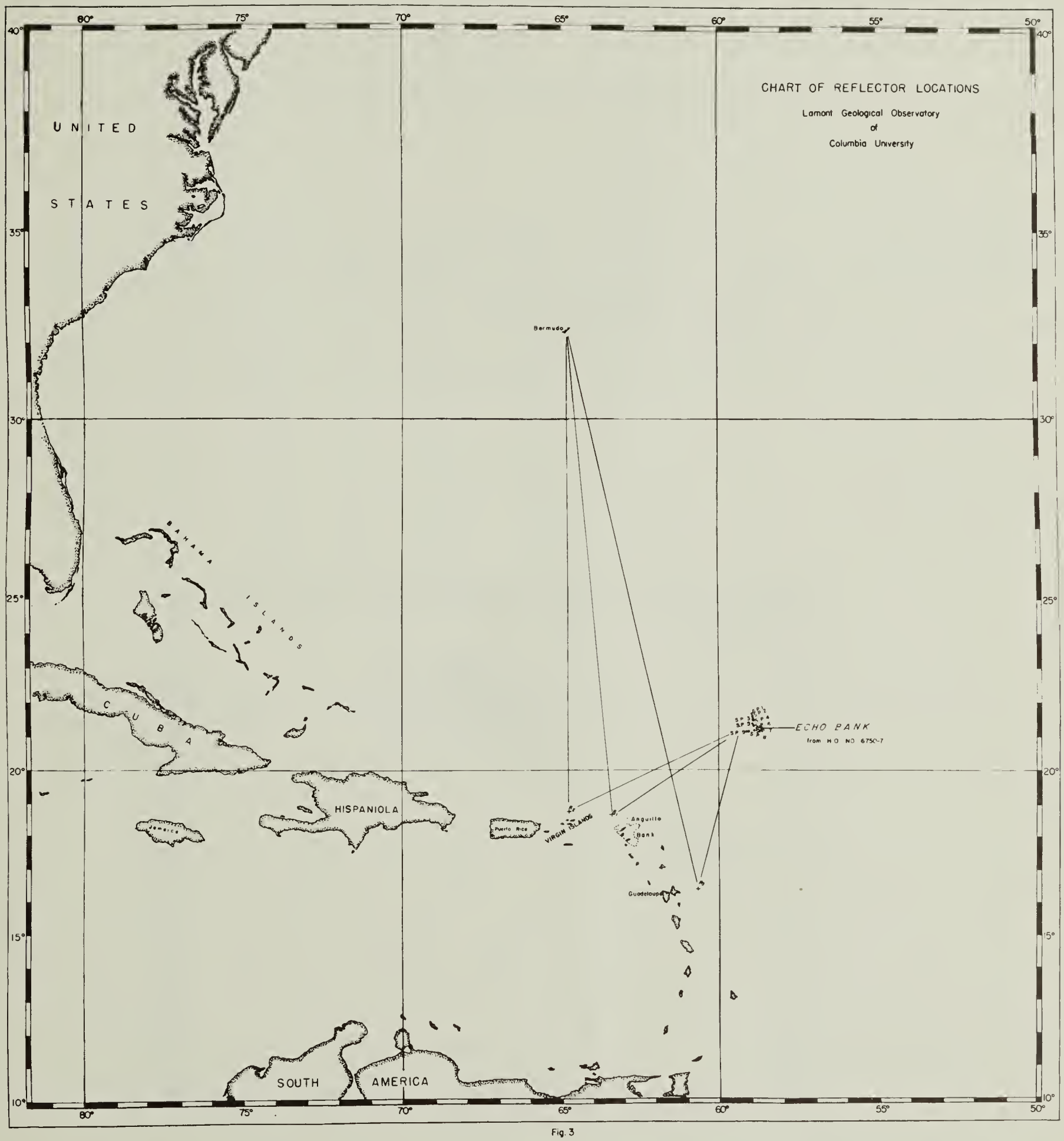
CHART OF REFLECTOR LOCATIONS
Lamont Geological Observatory
of
Columbia University
UNITED
STATES
Bermuda
BAHAMA
ISLANDS
CUBA
HISPANIOLA
Jamaica
Puerto Rico
VIRGIN ISLANDS
Anguilla
Bank
Guadeloupe
ECHO BANK
from H O NO 6750-7
SOUTH
AMERICA
80°
75°
70°
65°
60°
55°
50°
40°
35°
30°
25°
20°
15°
10°

Fig. 3

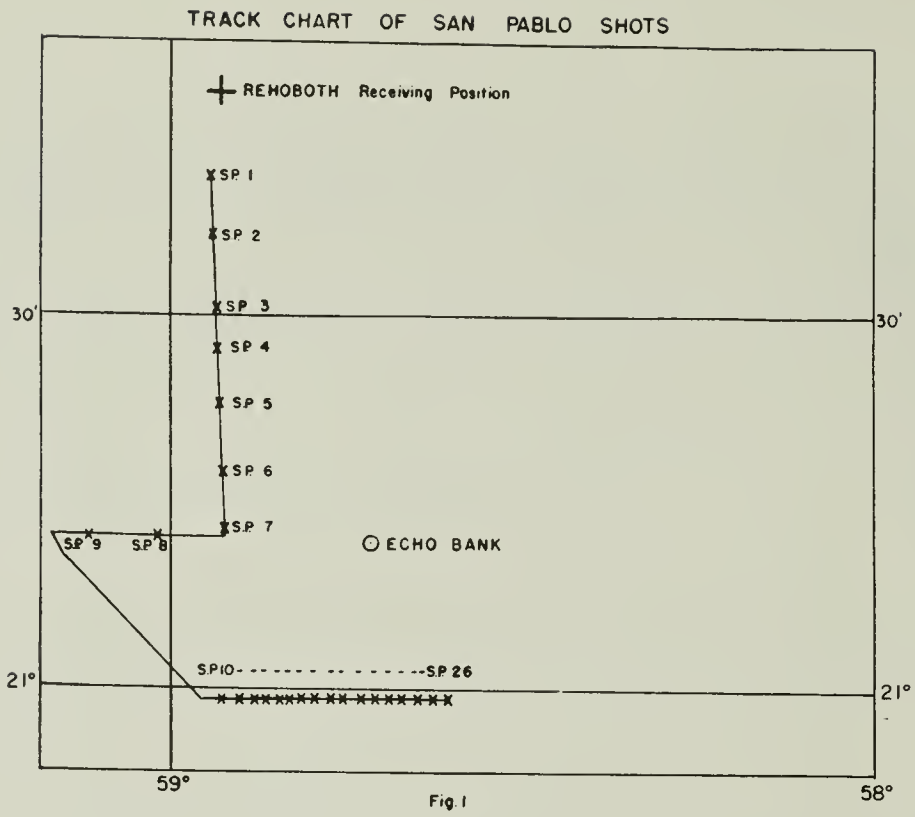
TRACK CHART OF SAN PABLO SHOTS
REHOBOTH Receiving Position
S.P. 1
S.P. 2
S.P. 3
S.P. 4
S.P. 5
S.P. 6
S.P. 7
S.P. 9
S.P. 8
ECHO BANK
S.P. 10
S.P. 26
30'
21°
59°
58°

Fig. 1

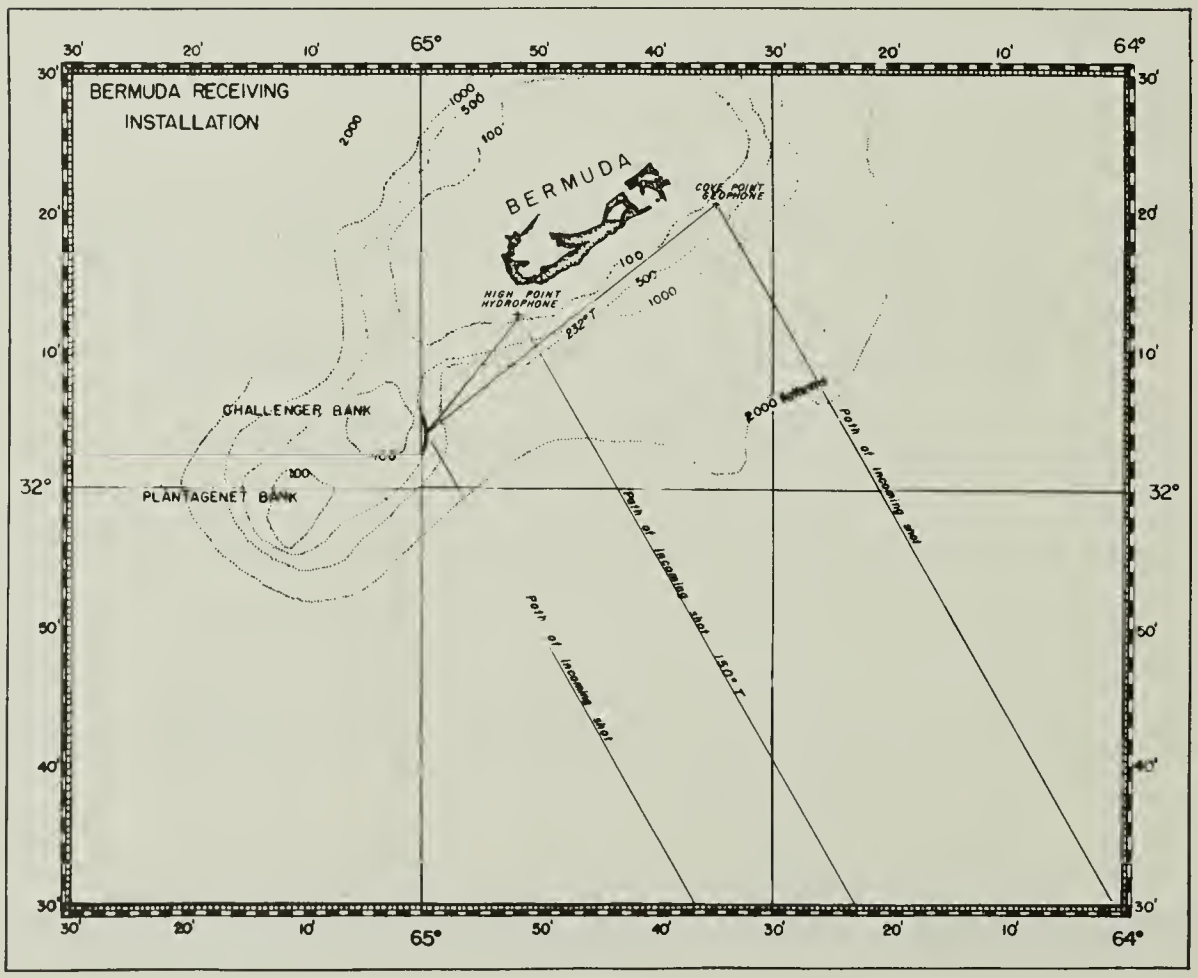
BERMUDA RECEIVING INSTALLATION
BERMUDA
COVE POINT HYDROPHONE
HIGH POINT HYDROPHONE
232° T
CHALLENGER BANK
PLANTAGENET BANK
Path of incoming shot
Path of incoming shot 152° T
Path of incoming shot
65°
64°
32°

Fig. 2

TABLE I

Shot Data

Phase I

Shot No.	Charge Size lb.	Shot Depth fm	Lat. Deg.	North Min.	Long. Deg.	West Min.	Date	Shot Time (Greenwich) Hr.	Min.	Sec.
SP 1	60	600	21	41	58	56.6	6 Mar 1953	12	19	55*
SP 2	60	600	21	36.2	58	56.5	"	12	50	25
SP 3	60	600	21	30.4	58	56.3	"		D U D	
SP 4	60	600	21	27.3	58	56.1	"	13	42	17
SP 5	55	600	21	22.7	58	56	"	14	08	49
SP 6	55	600	21	17.7	58	55.8	"	14	40	01
SP 7	55	600	21	12.8	58	55.7	"	15	56	18
SP 8	55	600	21	12.2	59	01.3	"	16	27	37
SP 9	55	600	21	12.2	59	06.4	"	17	00	20

*Shot not recorded. Time is calculated from arrival time at Bermuda and travel time from succeeding shots.

TABLE II

Travel Time Data

Phase I

Shot No.	Charge Size lb.	Shot Depth fm	Hydro-phone	Travel Time-Seconds Direct Path	R1	R2	R3
SP 1	60	600	CP	877	1403	1466	1621
			HP	876.5	1393	1456	1616
SP 2	60	600	CP	885.1	1400.8	1460.8	1618.4
			HP	884.6	1395.3	1454.8	1613.8
SP 3	60	600	CP		D U D		
			HP				
SP 4	60	600	CP	894.6	1394.6	1451.3	1606.9
			HP	Instrument not recording			
SP 5	55	600	CP	899.2	Unknown shot masks echoes		
			HP	Instrument not recording			
SP 6	55	600	CP	905.8	1392.9	1555.9	1598.8
			HP	905.5	1386.0	1447.8	1595.3
SP 7	55	600	CP	909.8	1384.2	1450.7	1591.1
			HP	909.3	1377.3	1443.6	1588.1
SP 8	55	600	CP	902.2	Ship over Cove Point instrument		
			HP	901.9	1366.8	1427.7	1579.8
SP 9	55	600	CP	903.9	1373.6	1438.8	1583.0
			HP	903.4	1366.4	1429.4	1588.1

direct wave does not vary with changing shot locations. (b) It is received on all shots by the High Point hydrophone but never by the Cove Point geophone, whereas the direct waves are received by both. The reflector responsible for this echo has been determined as the edge of Challenger Bank and the calculated travel time for an echo from this location to the High Point phone is in good agreement with the observed time. In addition it will be noted that an echo from this location would approach the Cove Point geophone from 230° T (Fig. 3), which is beyond the cut-off azimuth for the geophone. This explains the consistent absence of this echo from the geophone record.

The travel times of the echoes (observed and calculated) are listed in Table III and the last column in the table lists the deviation of the measured time from the calculated time (based on 4900 ft/sec). No deviation was found to be as great as 10 seconds and this is well within the reasonable limits since the calculations suppose a point reflector and the actual reflector is undoubtedly a broad surface. The method of obtaining the solutions is the same as that given in Luskin et al. (Submarine Topographic Echoes from Explosive Sound, Bull. Geol. Soc. Amer. Oct. 1952 p. 1063), except that one of the symmetrical solutions is eliminated by the directional feature of a two-instrument installation.

SUMMARY

The conclusion drawn from this investigation is that there is no topographic feature in the vicinity of the reported location of Echo Bank which produced an echo, although echoes were received from topographic features as far away as 300 miles from the shot location and 975 miles from Bermuda. This indicates that if any topographic feature exists, the minimum sounding is greatly in excess of the reported 34 fathoms. This conclusion is substantiated by the fact that an echo has been received at Bermuda from a seamount located at $32^{o}00'N$ $58^{o}50'W$ which has a minimum sounding of 1270 fathoms.

A further result of this investigation is the identification of Challenger Bank as a reflector for the High Point installation. Sound does not arrive at the Cove Point geophone from this reflector due to the topographic cut-off adjacent to the instrument.

It is essential to have SOFAR bombs with fast, consistent sinking rate and an effective system to monitor them from the shooting vessel if searches for seamounts by the acoustical shadow method are to be effective.

TABLE III

Reflector 1... Anguilla Bank .. 18°40'N 63°25'W.. 823 miles to geophone
817 miles to High Point

Shot No.	Distance Miles	Total Path Miles	Calc. TT Sec.	Meas. TT Sec.	Deviation from Meas. TT Sec.
Geophone					
SP 1	311	1134	1407	1403	+4
SP 2	306	1129	1401	1401	0
SP 3		D U D			
SP 4	304	1127	1398	1395	+3
SP 5	301	1125	1396	Unknown shot masks echoes	
SP 6	299	1122	1392	1393	-1
SP 7	296	1119	1388	1384	+4
SP 8	291	1114	1382	Ship over geophone	
SP 9	287	1110	1377	1374	+3
High Point					
SP 1	311	1128	1399	1393	+6
SP 2	306	1122	1393	1395	-2
SP 3		D U D			
SP 4	304	1120	1390	Instrument not recording	
SP 5	301	1118	1388	Instrument not recording	
SP 6	299	1116	1384	1386	-2
SP 7	296	1114	1380	1377	+3
SP 8	291	1108	1374	1367	+7
SP 9	287	1103	1369	1366	+3

TABLE III (cont'd)

Reflector 2 .. Virgin Islands .. 18°52'N 64°48'W.. 809 miles to geophone
801 miles to High Point

Shot No.	Distance Miles	Total Path Miles	Calc. TT Sec.	Meas. TT Sec.	Deviation from Meas. TT Sec.
Cove Point					
SP 1	370	1179	1463	1466	-3
SP 2	368	1177	1460	1461	-1
SP 3		D U D			
SP 4	364	1173	1455	1452	+3
SP 5	362	1171	1453	Unknown shot masks echoes	
SP 6	361	1169	1450	1456	-6
SP 7	359	1168	1449	Ship over instrument	
SP 8	354	1163	1443	1452	-9
SP 9	349	1158	1437	1439	-2
High Point					
SP 1	-	-	-	-	
SP 2	368	1168	1450	1455	-5
SP 3		D U D			
SP 4	364	1164	1445	Instrument not recording	
SP 5	362	1162	1443	Instrument not recording	
SP 6	361	1161	1440	1448	-8
SP 7	359	1159	1439	1443	-4
SP 8	354	1154	1433	1428	+5
SP 9	349	1149	1427	1429	-2

TABLE III (cont'd)

Reflector 3... Guadeloupe .. 16°25'N 60°40'W .. 979 miles to geophone
975 miles to High Point

Shot No.	Distance Miles	Total Path Miles	Calc. TT Sec.	Meas. TT Sec.	Deviation from Meas. TT Sec.
Cove Point					
SP 1	330	1309	1624	1621	+3
SP 2	325	1304	1618	1618	0
SP 3		D U D			
SP 4	316	1295	1607	1607	0
SP 5	311	1290	1601	Unknown shot	masks echoes
SP 6	307	1286	1596	1600	-4
SP 7	302	1281	1589	1591	-2
SP 8	299	1278	-	Ship over instrument	
SP 9	297	1276	1583	1587	-4
High Point					
SP 1	330	1305	1619	1616	+3
SP 2	325	1300	1613	1614	+1
SP 3		D U D			
SP 4	316	1291	1602	Instrument not recording	
SP 5	311	1286	1596	Instrument not recording	
SP 6	307	1282	1591	1595	-4
SP 7	302	1277	1584	1588	-4
SP 8	299	1274	1581	1580	-1
SP 9	297	1272	1578	1583	-5